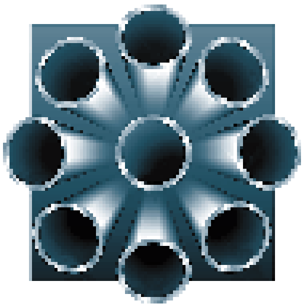

Seamless tube

Sandvik 254 SMO

S-1884-ENG April 1999 • Cancels all previous editions

Sandvik 254 SMO™ is an austenitic stainless steel of the ELC type developed for use in seawater and other aggressive chloride-bearing media. The steel is characterised by the following properties:

- *excellent resistance to pitting and crevice corrosion*
- *high resistance to general corrosion*
- *high resistance to stress corrosion cracking*
- *higher strength than conventional austenitic stainless steels*
- *good weldability*

CHEMICAL COMPOSITION (NOMINAL), %

C max.	Si max.	Mn max.	P max.	S max.	Cr	Ni	Mo	N	Cu
0.020	0.80	1.00	0.030	0.010	20	18	6.1	0.20	0.7

STANDARDS

Type of steel

- UNS S31254
- EN 1.4547[a)]
- W.-Nr. 1.4529[b)]
- DIN X 2 CrNiMoCuN 20 18 6
- AFNOR Z1 CNDU 20.18.06AZ
- SS 2378

Product standards

Seamless tube and pipe: ASTM A269, A312, NFA 49-217
Welded tube and pipe: ASTM A249, A269 , A312, A358; A409
Fittings: ASTM A182
Bars: ASTM A276, A479, EN 10088-3[a)]
Forged products: ASTM A473

Approvals

Tube and pipe, fittings and flanges
UNS S31254 (254 SMO) has been approved by the American Society of Mechanical Engineers (ASME) for use according to ASME Boiler and Pressure Vessel Code section VIII, div. 1.

a) According to EN 10088, valid for sheet/plate, strip, semifinished products, bars, rods and sections for general purposes (not for pressure purposes).
b) Nearest equivalent grade
c) $R_{p0.2}$ and $R_{p1.0}$ correspond to 0.2% and 1.0% offset yield strength respectively.
d) Based on $L_0 = 5.65\sqrt{S_0}$, where L_0 is the original gauge length and S_0 the original cross-section area.

FORMS OF SUPPLY

Seamless tube and pipe – Finishes and dimensions
Seamless tube and pipe are supplied in dimensions up to 230 mm outside diameter in the solution annealed and white-pickled condition or in the bright-annealed condition.

Other forms of supply

- Welded tube and pipe
- Fittings and flanges
- Bar steel
- Forged products
- Cast products

MECHANICAL PROPERTIES

The following values apply for material in the solution annealed condition.

At 20°C (68°F)

Metric units

Proof strength $R_{p0.2}$ c) MPa min.	$R_{p1.0}$ c) MPa min.	Tensile strength R_m MPa	Elong. A d) % min.	$A_{2"}$ % min.	Hardness Vickers approx.
300	340	650-850	35	35	180

Imperial units

Proof strength $R_{p0.2}$ c) ksi min.	$R_{p1.0}$ c) ksi min.	Tensile strength R_m ksi	Elong. A d) % min.	$A_{2"}$ % min.	Hardness Vickers approx.
43.5	49.3	94.2-123.3	35	35	180

1 MPa = 1 N/mm²

Impact strength

Its austenitic structure gives 254 SMO very good impact strength, both at room temperature and at low temperatures.

At high temperatures

Intermetallic phases are precipitated within the temperature range of 600-1000°C (1110-1830°F). The steel should therefore not be exposed to these temperatures for prolonged periods.

Temperature °C	Proof strength $R_{p0.2}$ MPa min.	$R_{p1.0}$ MPa min.	Temperature °F	Proof strength $R_{p0.2}$ ksi min.	$R_{p1.0}$ ksi min.
100	230	270	200	34.2	40.0
200	190	225	400	27.4	32.5
300	170	200	600	24.4	28.8
400	160	190	700	23.6	28.0

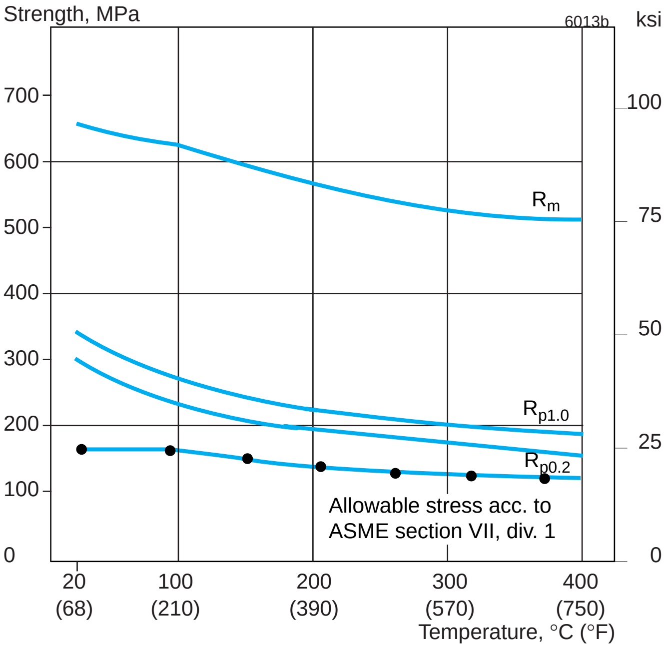

Figure 1. Strength values (min. values) for 254 SMO and allowable stress according to ASME Boiler and Pressure Vessel Code section VIII, div. 1.

PHYSICAL PROPERTIES

Density, 8.0 g/cm³, 0.29 lb/in³

Thermal conductivity

Temperature °C	W/m °C	Temperature °F	Btu/ft h °F
20	10	68	6
100	12	200	7
200	14	400	8
300	16	600	9.5
400	18	800	10.5
500	20	1000	11.5
600	21	1200	12.5
700	23	1300	13

Specific heat capacity

Temperature °C	J/(kg °C)	Temperature °F	Btu/(lb °F)
20	485	68	0.12
100	510	200	0.12
200	535	400	0.13
300	565	600	0.14
400	585	800	0.14
500	600	1000	0.14
600	615	1200	0.15
700	625	1400	0.15

Thermal expansion, mean values in temperature ranges ($x10^{-6}$)

Temperature °C	Per °C	Temperature, °F °F	Per °F
30-100	16	86-200	9
30-200	16	86-400	9
30-300	16.5	86-600	9
30-400	16.5	86-800	9.5
30-500	17	86-1000	9.5
30-600	17	86-1200	9.5
30-700	17.5	86-1300	10

Modulus of elasticity, ($x10^{3}$)

Temperature °C	MPa	Temperature °F	ksi
20	195	68	28.3
100	190	200	27.6
200	182	400	27.5
300	174	600	25.1
400	166	800	23.8
500	158	1000	22.5

CORROSION RESISTANCE

Introduction

In solutions containing halides such as chloride and bromide ions, conventional stainless steels can be readily attacked by local corrosion in the form of pitting corrosion, crevice corrosion or stress corrosion cracking. In acid environments, the presence of halides also accelerates general corrosion.

In pure sulphuric acid, 254 SMO is much more resistant than AISI 316, and in naturally aerated sulphuric acid containing chloride ions 254 SMO exhibits higher resistance than 904L, see figure 2.

Stress corrosion cracking

Ordinary austenitic steels of the AISI 304 and 316 type are prone to stress corrosion cracking in chloride-containing solutions at temperatures exceeding about 60°C (140°F). For the austenitic steels, resistance to SCC increases with increasing nickel and molybdenum contents. The tables below give the results of two accelerated tests, showing that 254 SMO has a very good resistance to SCC.

Stress corrosion cracking tests in boiling 25% NaCl solution, pH = 1.5. U-bend specimens.

Steel	Time to failure	Remark
AISI 316	<150 h	Pitting
904L	No failure (1000 h)	Crevice corrosion
254 SMO	No failure (1000 h)	No attack

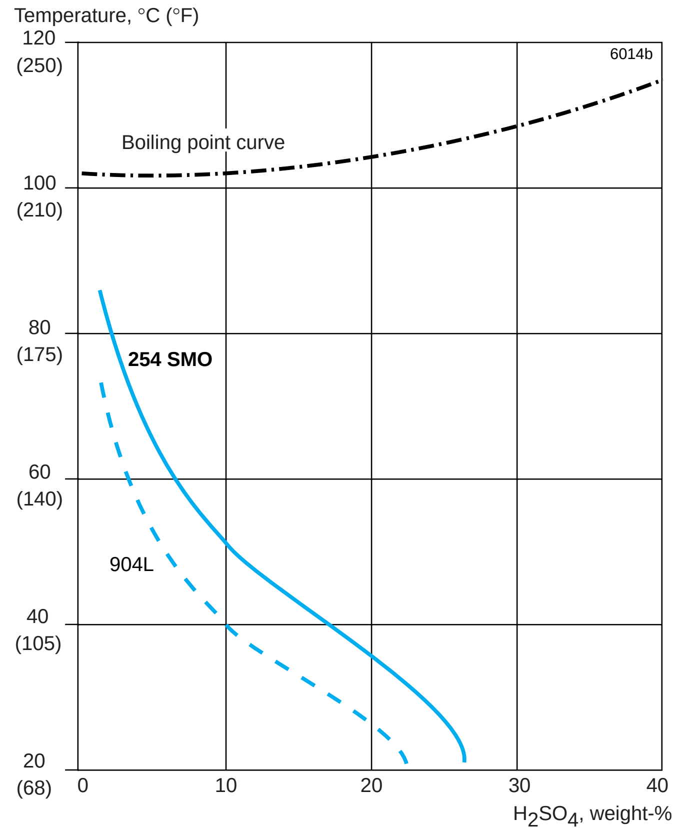

Figure 2. Isocorrosion diagram, 0.1 mm/year (4 mpy) in naturally aerated sulphuric acid containing 2000 ppm chloride ions.

Stress corrosion cracking tests. Drop evaporation method.*
Stress: 0.9 x $R_{p0.2}$

Steel	Time to failure, hours
AISI 316	105
904L	225
254 SMO	425

** A 0.1 M NaCl solution is allowed to drop slowly onto an electrically heated (300°C, 570°F) tensile test specimen.*

Intergranular corrosion

254 SMO has a very low carbon content. This means that there is very little risk of carbide precipitation during heating, for example when welding. The steel passes the Strauss test (ASTM A262, practice E) even after sensitising for one hour at 600-1000°C (1110-1830°F).

However, due to the high alloying content of the steel, intermetallic phases can precipitate at the grain boundaries in the temperature range at 600-1000°C (1110-1830°F). These precipitations do not involve any risk of intergranular corrosion in the environments in which the steel is intended to be used. Thus, welding can be carried out without any risk of intergranular corrosion.

Pitting corrosion

Its high chromium content and particularly the molybdenum content give 254 SMO excellent resistance to pitting and crevice corrosion. The high nitrogen content also improves pitting resistance.

The results of laboratory determination of the critical pitting temperature (CPT) in 3 % NaCl are shown in figure 3, where it can be seen that 254 SMO possesses very good resistance in water containing chlorides. 254 SMO is therefore a suitable material for use in for example seawater.

Crevice corrosion

The weak point of conventional stainless steels is their limited resistance to crevice corrosion. In seawater, for example, there is a considerably greater risk of crevice corrosion under gaskets, deposits or fouling. Tests in natural seawater at 60°C (140°F) have shown that 254 SMO can be exposed for prolonged periods without suffering crevice corrosion.

Figure 4 shows the results of accelerated crevice corrosion tests.

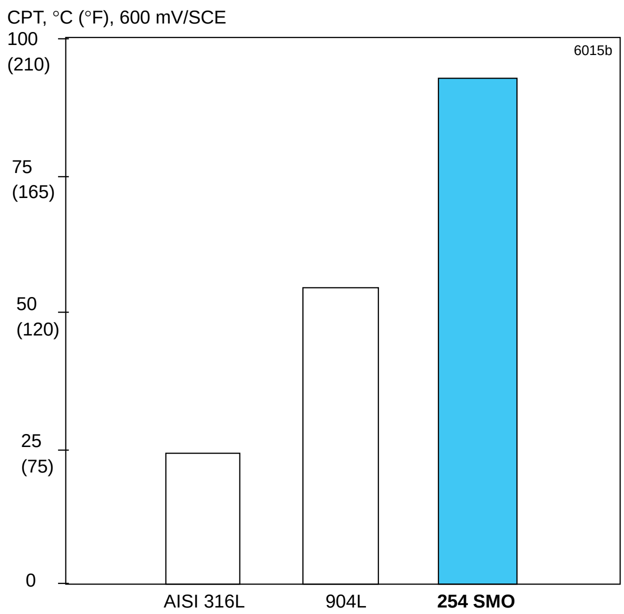

Figure 3. Critical pitting temperature (CPT) in 3 % NaCl, 600 mV/SCE.

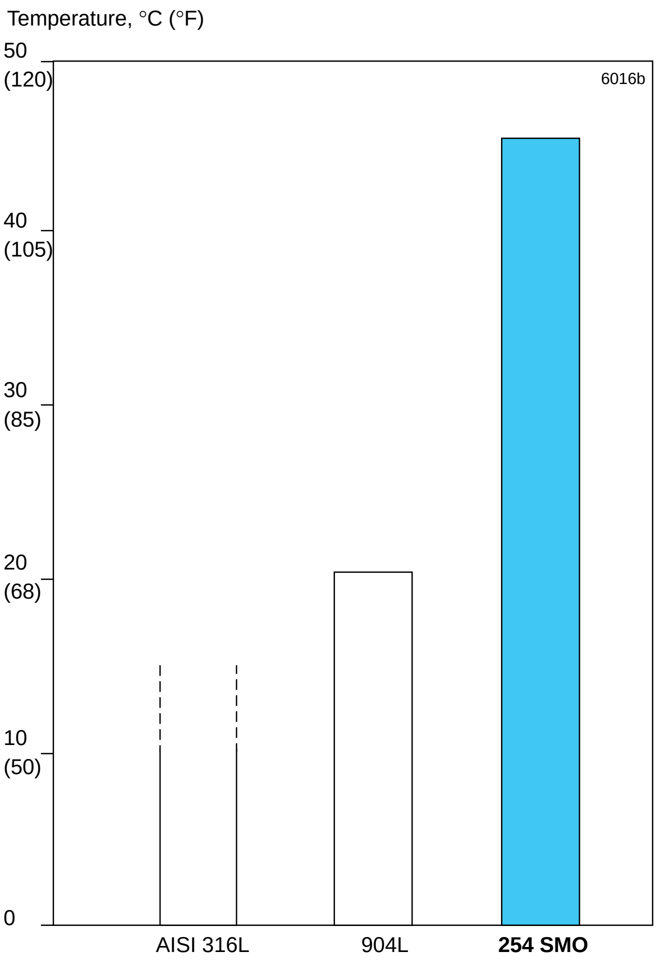

Figure 4. Critical crevice corrosion temperature in $FeCl_3$ for 254 SMO, AISI 316L and 904L. According to ASTM G-48.

HEAT TREATMENT

The tubes are delivered in heat treated condition. If another heat treatment is needed due to further processing the following is recommended.

Solution annealing

1150-1200°C (2100-2190°F), quenching in water.
Thin-walled tubes min 1130°C (2060°F), quenching in air/water.

WELDING

The weldability of 254 SMO is good. Welding should be done without preheating, and if correctly performed there will be no need for any subsequent heat treatment either. Suitable methods of fusion welding are manual metal-arc welding with covered electrodes and gas-shielded arc welding, mainly by means of the TIG and MIG methods.

Since the material is intended for use under severe corrosion conditions, welding must be carried out with care and followed by thorough cleaning to ensure that the weld metal and the heat-affected zone will have as good corrosion properties as possible.

The heat input during welding should not exceed 1.5 kJ/mm, and in multi-pass welding the interpass temperature should not exceed 100°C (210°F). A stringer bead welding technique should be used.

The welding of fully austenitic steels usually entails a risk of hot-cracking in the weld metal, particularly if the weldment is under constraint. However, since 254 SMO has a very high degree of purity, the risk of this type of cracking is greatly reduced. Backing bars and similar devices of copper alloys may, however, not be used since copper penetration into the grain boundaries in stainless steel can lead to cracking.

In common with all austenitic stainless steels, 254 SMO has low thermal conductivity and high thermal expansion. For this reason, welding should be carefully planned in advance so that distorsion of the welded joint can be minimised. If, despite these precautions, it is believed that residual stresses may impair the function of the weldment, it is recommended that the entire structure be solution annealed, see under "Heat treatment".

In the as-supplied condition, the material has a homogeneous structure. Welding without filler metal leads to structural changes that reduce corrosion resistance. Such welding should be followed by solution annealing in order to ensure that the corrosion properties of the weld metal are equal to those of the parent metal.

Wire and electrodes of Sandvik Sanicro 60 are recommended as filler metal. This filler metal is overalloyed and produces a weld that has better corrosion properties than the parent metal. Sanicro 60 is also suitable for welding of joints between 254 SMO and nickel alloys, other stainless steels or carbon steels.

FABRICATION

Avoid abrasion against copper/copper alloys or other similar metals which, if present in metallic form, can cause cracks during subsequent welding, hot processing or heat treatment.

Bending

The excellent formability of 254 SMO permits cold bending to very small bending radii. Annealing is not normally necessary after cold bending.

Machining

254 SMO is a high alloyed austenitic stainless steel and thus tougher inserts in metal cutting are needed than is the case for lower alloyed austenitic grades. When machining 254 SMO considerably lower cutting speeds are recommended compared to the grades SANMAC 304/304L and SANMAC 316/316L with improved machinability.

APPLICATIONS

254 SMO is used in the following applications:

- Equipment for handling of seawater, for example heat exchangers, cooling water pipes, ballast water systems, fire-fighting systems etc.
- Hydraulic and instrument tubing
- Equipment in pulp bleaching plants
- Components in gas cleaning systems.
- Tanks and pipelines for chemicals with high halide contents.

FURTHER INFORMATION

The following publication can be ordered from your nearest Sandvik office for additional information:

S-133-ENG "Stainless steel products for oil and gas production"

Recommendations are for guidance only, and the suitability of a material for a specific application can be confirmed only when we know the actual service conditions. Continuous development may necessitate changes in technical data without notice.

SANDVIK Steel

S-1884-ENG, April 1999
Cancels October 1993

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Printed in Sweden on environmetally-friendly paper. Sanmedia/Reklamtryckeriet, Köping